CRC

Research Centre
Centre de recherches
sur les communications

Communications Research Centre

Business

Plan
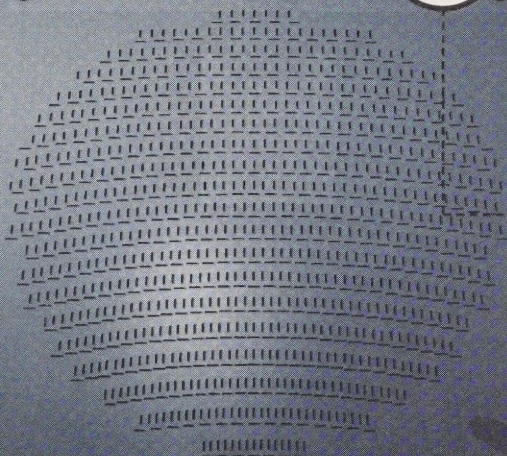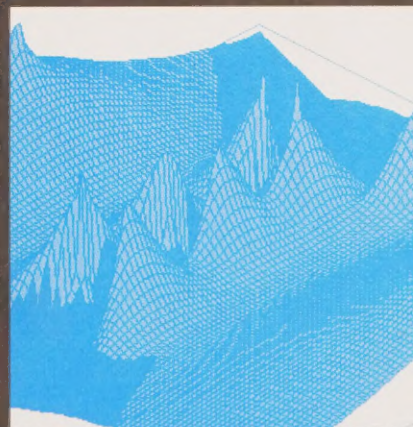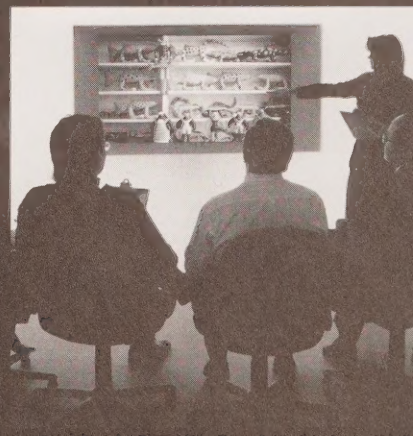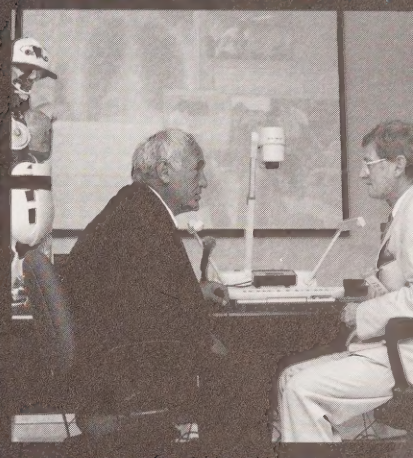
CRC

1997-1998

Industry Industrie
Canada Canada

Business Plan

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Research and Development Plan

The Communications Research Centre (CRC) is an institute of Industry Canada dedicated to applied research and development in communications technologies for the benefit of Canadians wherever they live.

Having evolved from predecessor organizations established to serve military communications needs, CRC began its civilian transformation under the Department of Communications in 1969. An agency of Industry Canada since 1993, for the first time in its organizational life CRC is integrated within the federal government's key department for economic development while continuing to serve its other major clients such as DND and CSA.

Never has there been a better opportunity for CRC to act as an advisor on policy, regulatory and industrial development issues relating to communications. And never have those issues been more sharply in focus than at the present, with an unprecedented range of technologies on the verge of exploding into the marketplace.

At the same time, CRC must confront the fiscal reality of reduced federal funding and develop revenue generation streams to help maintain its core competencies and grow in new areas. To preserve its long history of R&D excellence for which it has gained an international reputation over five decades, the CRC must distinguish itself within the mix of other federally funded laboratories and private sector organizations and concentrate its finite resources on areas in which it excels.

The 1997-98 CRC Business Plan presents CRC's position as a research institute within Canada's national innovation system. The plan outlines as its corporate goals:

- leadership in provision of objective scientific and technical advice to the federal government for the formulation of communications policies and regulations;

- catalyst in industrial and institutional partnerships that maintain Canada's world leadership in the development and application of communications technologies;

- supporting the federal government's jobs and growth agenda through sustained and measurable contribution to building an entrepreneurial and innovative communications industry in Canada.

Recognizing the explosion of digital technologies that represent the next wave of development in Canada's Information Highway infrastructure, CRC is focusing on wireless communications R&D as its principal line of business. CRC's traditional core competency areas will work toward activities associated with this business line. They include:

- satellite systems and components;

- digital radio broadcasting and advanced television systems;

- radio science, covering propagation and electromagnetic compatibility;

- terrestrial wireless communications systems, ranging from HF to EHF combined with selected areas related to:
  - broadband communications systems
  - optoelectronics and photonics components and applications demonstrations in these fields.

Strategies in support of its business direction include:

- flattening of the research management structure and realignment of the 10 research directorates into five program areas, each headed by a Director General: Satellite Communications; Terrestrial Wireless Systems, Broadcast Technologies; Broadband Network Technologies and Radio Science;

- increasing cross-core R&D project team work to address wireless/wireline networking and interoperability issues;

- developing of new partnerships based on complementary skills of other organizations; and

- increasing emphasis on demonstrator initiatives to illustrate linkages between new technologies and the potential for economic growth.

The Communications Research Centre, an institute of Industry Canada, conducts leading-edge research and development in a broad range of communications technologies on a 600 hectare site located at Shirleys Bay, west of Ottawa.

Founded on primary capabilities in radio propagation and radio communication, particularly at high latitudes, CRC's R&D has been driven by the needs of providing communications and broadcast services to all Canadians, including those in remote areas, and defence communications. CRC's applied research has historically featured a high degree of industrial participation and the organization has gained an international reputation for innovation in communications.

Today, CRC has a leading concentration of scientific and technical expertise in a number of fields of wireless communications, including terrestrial and satellite communications, broadcast technology, radio science and supporting component design. Complementing this is expertise in optoelectronics and photonics which are the foundation of broadband communications and the source of international awards and numerous Canadian and international patents.

While R & D is CRC's primary function, other competencies include:

- Provision of expert, impartial advice relevant to the development of national and international regulations and standards for the operation of communications services;

- Management and execution of comprehensive R&D programs, in particular defence and satellite communications programs;

- Expert contribution to the work of national and international communications research consortia and networks;

- Design and operation of accessible facilities for demonstrating new concepts and applications; and

- Transfer of communications technologies and know-how to Canadian industry — some 180 licences and 100 other intellectual property agreements; almost 60 companies trace their roots to CRC R&D programs.

Business Environment

The business environment is characterized by continuous and sometimes dramatic change, global opportunities, market restructuring and expanded competition. Government policies are shifting to reflect new international business realities and to create conditions for a dynamic, internationally competitive communications sector delivering high value to consumers.

CRC must be adaptive to take advantage of opportunities and maximize its value to the Canadian government, industry and taxpayers. At the same time, CRC must maintain continuity in those research competencies that underpin a range of new technology-based services. The forces at work fall into four related categories:

Technology

- Information and communication technologies are advancing at a breathtaking pace, prompted in part by exponential growth of the Internet which is emerging as the main lane of the Information Highway.

- Convergence of telecommunications, computing and broadcasting is resulting in the emergence of new players and restructuring of traditional industry sectors. New technological challenges arise, such as the need for efficient design and interoperability of networks.

- Rapidity and complexity of technological change require organizations to adapt and move quickly to seize new opportunities.

Markets and Business

- Demand for telecommunication equipment and services is rising, especially for wireless systems.

- In established markets, consumers face unprecedented choice among services and suppliers. In developing markets, half the world's population has yet to make their first phone call.

- Liberalization of trade in telecommunications by the World Trade Organization will create global opportunities for companies with competitive technologies. The role of international players in Canada will also increase.

Government Communications Policies

- The market-driven approach in setting policies results in a competitive situation where some ventures will win and others will lose. In order to secure the best communications services for the Canadian population the government needs to keep a high level of technical expertise to be able to select the most scientifically sound proposals.

- Recent licence awards for PCS, LMCS and direct to home (DTH) broadcast services, part of a general move toward a more market-driven approach to licensing, have brought new players into the Canadian market, with attendant commitments to R&D.

- The recently announced convergence policy recognizes and advocates moves toward the integration of services and increased opportunity for suppliers to participate.

- Market forces and new technological possibilities are driving innovation in the allocation of unused frequency bands, requiring leadership by government and quick, technically sound responses by government and industry working together.

Government S&T Policies

- The 1995 Federal S&T Strategy emphasized the need for federal R&D to lead to optimum public policy. At the same time, laboratories are expected to target resources on areas not normally addressed by the private sector, and to feature private sector and academic partnerships in R&D programs.

- The Auditor General of Canada, in 1995, reinforced the need for partnerships to increase collaboration, combine resources and eliminate duplication.

Given the market forces that are shaping the world economy and the declining resources that are available to governments, the Communications Research Centre has examined its fundamental operations and redefined its mission and mandate to reflect the new realities.

CRC Mission

- To be the federal government's centre of excellence for communications R&D, ensuring an independent source of advice for public policy purposes.

- To help identify and close the innovation gaps in Canada's communications sector by:
  - engaging in industry partnerships;
  - building technical intelligence;
  - supporting small and medium-sized high technology enterprises.

CRC Vision

National leadership in collaborative research and development on innovative communications, broadcasting and information technologies for a strong Canadian knowledge-based economy.

Corporate Goals

- To be at the forefront of communications science and technology, in order to offer insight to the government for the formulation of industrial strategies, regulations and policies in the public interest.

- To be recognized nationally and internationally as a leading centre of excellence in communications technology R&D addressing Canadian needs and a primary source of independent technical and scientific advice.

- To be a catalyst and central player in a web of industrial and institutional partnerships to ensure Canada maintains its world leadership position in the development and application of communications technologies.

- To make sustained and measurable contributions to the growth of an entrepreneurial, innovative communications industry in Canada

Strategies

The following strategies are key to the realization of the CRC vision and corporate goals:

- Identification of emerging technologies and solution of technical issues that are critical to services and applications in the emerging regulatory framework and the broadband communications systems and networks of the future.

- Increased efforts to bring together core R&D capabilities to address wireless/wireline internetworking and interoperability.

- New partnerships founded on the complementary skills of CRC and other organizations in areas such as satellite communications, emerging new wireless communications systems, advanced broadcasting, networking and related applications.

- Increased emphasis on major prototype and demonstrator initiatives to illustrate the link between innovative technologies and the potential for economic growth.

CRC's Place in the National Innovation System

CRC, acutely aware of the quickly evolving industrial and R&D infrastructure of which it is part, must assess and reinforce its leadership position in selected technologies to:

- be a catalyst in forging industrial alliances with complementary organizations to conduct collaborative R&D;

- focus on medium and long term market impacts;

- play a unique national role as an impartial, expert advisor for government, industry and the R&D community.

CRC is expanding its collaboration with organizations that have complementary capabilities including the National Research Council, TRLabs in Western Canada, the Canadian Centre for Marine Communications (CCMC) in Newfoundland, the Telecom Applications Research Alliance (TARA) in the Maritimes, and national and provincial centres of excellence such as the Canadian Institute for Telecommunications Research (CITR) and Communications and Information Technology Ontario. These collaborations provide continuity across the innovation spectrum, magnify collective effort, create research synergy and avoid duplication of research efforts.

The time horizon for the initial realization of the market impacts of CRC activities is generally three to seven years. Some activities will have short-term business impacts, but CRC will focus on how all its activities influence developments in the medium to long term.

Some CRC activities, such as the solution of basic radio propagation issues, digital broadcast technologies, miniature RF components and new antenna design concepts will be felt for many years. In addition, CRC plays an important role in the development of technical standards that will underpin Canada's Information Highway infrastructure for years to come. Therefore, CRC's work complements and bridges the research efforts of universities which tend to focus on long-term impacts, and industrial laboratories, which seek more immediate commercial results.

CRC is expanding its partnerships with companies that conduct complementary R&D, in order to enable these firms to benefit from CRC's special capabilities and to avoid competition with the private sector. These partnerships are carefully managed to enable CRC to occupy its unique position as the federal government's source of objective advice and information for policy, regulatory and industry development purposes. CRC is also continuing to play an important role representing Canada (both government and industry) in international bodies such as the International Telecommunications Union (ITU).

The Team

CRC is the Canadian government's leading communications research facility. With 200 research staff, CRC has exceptional talent and specialized expertise in communications R&D. Numerous researchers are internationally known in their respective disciplines. Many possess specialized scientific knowledge and skills sets that are unique in Canada. The know-how and experience of CRC's researchers are attractive to private companies, universities and other organizations seeking collaboration.

CRC is placing top priority on creating an environment that will continue to attract and retain top-notch talent. A combination of exciting research projects and flexible working arrangements make for a stimulating milieu.

Many CRC success stories are the product of the creative and entrepreneurial efforts of individuals who have spotted opportunities and pursued projects to fruition through competence, determination and goodwill.

In the past CRC has been successful in attracting both new employees and collaborating partners who have these attributes.

CRC is striving to obtain the best human resources, but faces an extremely competitive high technology labour market shortage, and must operate within governmental fiscal and administrative policy constraints. The human resource management program will address these issues by:

- making representations on compensation issues to federal authorities;

- expanding university recruitment with renewed emphasis on employment equity;

- developing competency profiles and training programs for career development.

The research community at CRC is bolstered by more than 150 staff who provide corporate support services and operate the site. Much work is done behind the scenes to facilitate the core research activities. From library services to running the heating plant, purchasing supplies or providing pay and benefits, CRC depends on its dedicated support staff. The corporate marketing group provides marketing assistance, conducts site tours, prepares licensing agreements and manages CRC's web site.

> The CRC will move forward aggressively to enhance the pace of business development with both internal and external clients. Priority will be given to developing close partnerships with the private sector and other organizations within the government.
>
> *Industry Canada Departmental Business Plan*

- CRC is strengthening its relationship with its principal funder, Industry Canada, establishing a new client-based relationship and creating new mechanisms for delivering advice and information.

- CRC is also strengthening its relationships with other government departments and agencies, starting with those in the Industry Portfolio.

- CRC is renewing its working arrangements with the Department of National Defence (DND) and the Canadian Space Agency (CSA), taking into account new goals and new fiscal realities in these client organizations, while targeting other government departments such as the Government Telecommunications and Informatics Services (GTIS).

- CRC is an active member on the two federal government task forces on the implementation of digital radio broadcasting and digital television.

The relationship with Industry Canada will encompass spectrum management plus other domains such as industry development and the Information Highway. Traditional ties to Spectrum Management are being fortified. CRC seeks to be more proactive to government requirements, helping to shape emerging regulatory and policy regimes and to be a partner in program and service delivery when appropriate.

CRC is clarifying its roles and implementing projects in support of government priorities such as the Information Highway, communications for remote and under-served areas of Canada and issues of privacy. These multi-faceted projects are carried out by teams from across the organization.

Jobs and Growth through CRC Technology Transfer

CRC is proud of its track record collaborating with companies to help advance the government's jobs and growth agenda and is expanding its strategic relationships with major industrial players where it can deploy special capabilities in joint undertakings for broad economic benefits.

CRC is also making a special effort to provide benefits for small and medium-sized companies through facilities such as the CRC Innovation Centre, the Broadband Applications and Demonstration Laboratory (BADLAB), the Satcom testbed and Advanced Television Evaluation Laboratory. CRC also helps companies through technology transfer agreements, collaborative R&D projects and the provision of information and advice.

Innovation Centre Plus

The CRC Innovation Centre is an instrument for R&D collaboration and technology transfer. Opened in late 1994, the Centre has graduated a number of excellent small companies with tremen-

dous growth potential, including Linmor Technologies and Innovative Fibres.

The CRC Innovation Centre will continue to act as a tool for all CRC to facilitate technology transfer to young technology companies and spinning off CRC technologies which could form the foundation for new companies. The centre's planning and activities will be fully integrated with CRC's R&D program. A working R&D or technology transfer relationship with CRC will continue to be a condition of residency.

As a national laboratory, CRC recognizes the need to reach out to companies across Canada. To do this, CRC has launched a two-pronged strategy:

National reach and impact will be aided by partnerships with organizations in other parts of Canada that facilitate access to CRC expertise and capabilities by helping small companies incubate. The first such partnership has been established with TARA in Halifax. Such support is also an element of agree-

ments with the CCMC in St. John's and the INRS Telecommunications in Laval, Quebec. Once further experience is gained in such relationships, new partnerships will be established with a goal of creating a network of collaborating organizations stretching across Canada.

CRC will continue to be a key player in the incubation of companies in the National Capital Region, and is expanding and strengthening its partnerships with organizations such as the Ottawa Carleton Economic Development Corporation (OCEDCO), the Ottawa Carleton Research Institute (OCRI), Cité 2001 in Hull, Quebec, and the NRC.

Linmor Technologies
A Growing Success

Linmor Technologies, a spin-off of Nortel, was one of the first clients to occupy space at the Communications Research Centre's Innovation Centre when it opened in 1994. Within a year, the company had signed up several clients for its family of network and systems management software, and has since moved twice to larger quarters. The company has grown from five employees in December 1994 to a complement of 30 today, and is bringing in sales of about $1 million a year. In May 1996, Linmor received funding assistance under NRC's Industrial Research Assistance Program to collaborate with CRC's Network Technologies Research Branch on development of a multi-vendor network management system for asynchronous transfer mode (ATM), broadband communications. In November 1996, Linmor won the New Business of the Year Award under the Ottawa-Carleton Business Achievement Awards Program.

Industry Portfolio S&T Progress Report

Research and Development Plan

As the Information Age unfolds, Canada, like all industrialized nations, is in the midst of a profound transition where manufacturing and primary industries are being overtaken by knowledge-based enterprises and telecommunications and information technologies as the powerful engines of economic growth.

Industry Canada has been at the forefront of the federal government's initiative in formulating strategies to assist Canadians in their adjustment to the new economy and position Canada for the global opportunities in high technology commerce that are emerging. A key strategy is the development of an integrated Information Highway so that Canadians can seize benefits from this new economy.

The demand for telecommunications equipment and services is exploding world-wide. Wireless communications, once a niche market, is projected to represent close to 50 percent of the North American telecommunications traffic by the year 2000. In developing nations where a public telephone infrastructure is lacking, wireless communications is likely to emerge as the only cost-effective means of bringing voice and data services to millions of people who currently do not have access to the most basic telecommunications services.

In Canada, the underlying infrastructure, or Information Highway, will provide everything from electronic banking to telemedicine and entertainment services and will combine wireline and wireless technologies designed to supply capacity, access, interoperability and security. Rapid advances in signal processing technology, digitization and miniaturization of electronics have made it possible for communications to become ubiquitous and user-friendly.

The Communications Research Centre has been committed to applied and basic research in a multidisciplinary field of communications and related technologies dating back to the late 1940s. For the better part of 50 years, the CRC and its predecessor organizations have significantly contributed to scientific and engineering achievements enhancing Canada's position as a world leader in wireless, satellite communications and broadcast technologies. As an institute of Industry Canada since 1993, CRC has continued its contributions to technical issues concerning management of the radio spectrum, the deployment of wireless communications and broadcast services, and new technologies and know-how for exploitation by Canadian industry. CRC is also the federal government's main laboratory for demonstrating novel high bandwidth applications for the Information Highway through its Broadband Applications and Demonstration Laboratory and associated testbeds.

With new initiatives such as the Advanced Satcom Program, the issue of licences for personal communications services (PCS) and local multipoint communications systems (LMCS), and the emerging digital radio broadcasting services, CRC is increasingly called on to contribute its R&D expertise to assist the Canadian government and industry.

In this context CRC has developed a research and development plan that recognizes the institute's traditional strengths, while positioning it to address the new realities of the rapid evolution in wireless and broadband communications.

Accordingly, the Communications Research Centre has identified a principal line of business:

■ Wireless Communications R&D

Complementing this line of business, and in concert with a vision that demonstrates national R&D leadership in telecommunications, broadcasting and information technologies, CRC will continue to enhance two associated activities that support Canada's Information Highway development:

- Broadband Networking, and

- Applications Demonstrations

The R&D plan that follows is based on the premise that CRC's traditional core competencies must work across organizational lines to support Industry Canada in its policy and economic development responsibilities and to assist Canadian industry in the development of Canada's Information Highway infrastructure.

By structuring its program in this manner, CRC will fulfil its vision of national leadership and excellence in communications R&D. For Canada's Information Highway to thrive, there are many technical issues that must be addressed. CRC's research and development plan is applying its core expertise to address these challenges.

To accomplish this plan, CRC is replacing its two existing research branches, Communications Systems Research and Radiocommunications and Broadcast Research, with a more streamlined research management structure. The ten research directorates will be combined into five program areas, each headed by a Director General who reports to the CRC President.

In addition, CRC is refining criteria and the process to prioritize research projects for allocation of appropriate resources. This will enable the institute to better evaluate new research proposals for funding.

> In supporting science and technology, the federal government should attach priority to Information Highway research aimed at enhancing the capacity, interoperability and interworking of high speed networks, and related applications.
>
> *Preparing Canada for a Digital World - Information Highway Advisory Council Conclusions and Recommendations, April 23, 1997.*

Wireless Communications

There is a vast array of current and planned wireless systems and services including:

- terrestrial personal communications services (PCS);

- terrestrial broadband wireless networks such as local multipoint communications systems (LMCS) and wireless local area networks (LAN);

- mobile and personal satellite communications; fixed, broadband satellite communications; and

- digital broadcast services.

Some of these wider bandwidth communications services will be implemented at higher radio frequencies. Furthermore, a convergence between wireline and wireless networks, and between fixed and mobile services, is emerging.

The major thrust of the wireless communications R&D program is to advance understanding of the wireless environment through radio science and to contribute to developing wireless technologies and systems which meet the future demands for high bit-rate services, while addressing issues of interoperability with wireline networks. Some of these challenges include:

- efficient and effective utilization of the radio frequency spectrum;

- reliability and integrity of the wireless links;

- interconnection of wireless and wired networks;

- security of the network and its content, and privacy of communications;

- establishment of global standards;

- development of key technologies.

An organization the size of CRC, with some 200 researchers, cannot address all of the possible R&D topics related to a field as broad as wireless communications. This plan outlines a program that takes full advantage of existing strengths to positively impact on areas important to future communications development.

CRC has unique Canadian expertise, competence and facilities in key areas of wireless communications, including terrestrial wireless, satellite communications, broadcast technology and radio science, as well as microwave components and antennas required to support them.

In satellite communications, CRC has the most comprehensive team of researchers and the best R&D facilities in Canada. In addition, CRC has been assigned the task of implementing the satellite communications elements of Canada's Long Term Space Plan.

In broadcasting, CRC is providing significant technical support for implementation of a domestic digital radio broadcasting service and digital television broadcasting including high definition television.

In radio science, CRC has made major contributions over the past four decades to the overall understanding of radio frequency (RF) propagation and electromagnetic interference issues. Dramatic increases in wireless links, will make this knowledge even more important. The characteristics, propagation effects and limitations of the spectrum need to be better understood below 30 gigahertz (GHz) to optimize performance of existing systems, and above 30 GHz because these bands may ultimately offer solutions to increase wireless service capacity.

> PCS devices have the potential to add a new dimension to the now-imminent competition in local telephone services. Having a wireless on-ramp to the Information Highway will also be important for remote or rural areas, where the cost of laying new high-capacity land lines may be prohibitive.
>
> *Building the Information Society: Moving Canada into the 21st Century*

Terrestrial Wireless

CRC's terrestrial wireless R&D program investigates technologies and systems for reliable and robust fixed, mobile and personal wireless communications that meet military and civilian requirements. CRC has embarked on R&D related to the technologies of emerging communications services such as LMCS and PCS. As well, CRC is developing advanced radio techniques and tools for telecommunications and spectrum surveillance in response to an Industry Canada requirement.

Specifically, CRC's R&D effort will focus on developing techniques and technologies to mitigate multipath fading and interference effects in radio systems to increase spectrum efficiency and capacity.

The R&D will include:

- signal design for communications over difficult channels;

- adaptive antenna techniques to locate and track various types of signals to dynamically minimize interference and maximize intended signal receptions; and

- direction finding systems for problem propagation environments, such as Canada's North.

An important element of CRC's R&D is the establishment of a wireless testbed, accessible to industry, for testing new techniques, technologies and applications and the interoperability of wireless and wireline networks.

For military communications, there is a growing requirement to provide strategic information in a mobile battlefield environment, demanding higher bandwidth radio systems. As well, DND's next generation of battlefield communications requires wireless local area networks that are portable, high-speed, and low in power consumption.

Such wireless requirements translate into the need for new microelectronic technologies to minimize power use, size and cost, and for small, high-performance antennas. Specific topics include the exploration and development of emerging microelectronics and antenna technologies for broadband

wireless including: silicon germanium (SiGe) semi-conductor components for microwave receivers and for mixed analog/digital implementation; high-speed ASIC's for broadband systems; and small, low-cost, Ka-band antenna concepts.

Possessing a reference knowledge base of radiocommunications technology is important to Industry Canada; it will allow the department to make decisions about deploying new wireless systems, their licensing, coordination and regulation. As well, DND and the North Atlantic Treaty Organization (NATO) partners are major clients for the R&D results. The transfer of knowledge and technology to industry are also important outcomes.

Current Year Objectives

In 1997-98, CRC is working on:

- investigating smart antenna, polarization-diversity and adaptive equalization techniques and other technologies for mobile cellular and personal wireless communications systems to increase system capacity and improve performance in high interference environments;

- beginning to develop a demonstration system, by adapting and applying commercial wireless technologies that provide for the extension of military information systems to the battlefield and enhance performance and survivability of the individual soldier;

- carrying out radio link analysis and simulation of the combat network radio and cellular radio systems being procured by DND;

- supporting the Canadian Navy in sea trials of Communications Systems Network Interoperability (CSNI) project which is the next stage in transferring the results of previous R&D carried out in cooperation with NATO organizations;

- developing system concepts and technologies for broadband wireless networks which address the demand for high-speed data/multimedia services;

- exploring and developing emerging microelectronics and antenna technologies for broadband

wireless communications systems with emphasis on frequencies above 20 GHz; and

- developing technologies for signal classification and monitoring for use in spectrum surveillance systems.

Satellite Communications

The satellite communications R&D program focuses on designing and simulating system concepts and developing key technologies and sub-systems for both existing and planned satellite networks. These include the North American MSAT and future mobile and personal multimedia satellite communications programs under the Canadian Advanced Satcom Program.

CRC collaborates with many of the over 100 Canadian companies which sell satellite communications-related products and services. This is done in part through the transfer of key technologies and by providing scientific guidance in planning industrial strategies under the satellite communications portion of Canada's Long Term Space Plan.

CRC also collaborates internationally with the European Space Agency (ESA) through contracting-in, and the German research institute, Deutsches Luftfahrt and Raum Institut (DLR), through a scientific exchange.

CRC is pursuing advanced communications signal design for more bandwidth and power-efficient transmission schemes, and broadband integrated electronics for future low cost multimedia terminals. Two antenna technologies currently under development include using dielectric materials to reduce size, and optical methods for signal distribution for antenna arrays.

On behalf of DND, CRC performs R&D on special military projects such as security and survivability of satellite communications systems. CRC represents Canada at various military technical fora. The work results in the transfer of key technologies to Canadian industries, the demonstration of advanced proof-of concept terminals and services, and the provision of an extensive technical knowledge base for Industry Canada in spectrum management and policy issues.

There are two major issues in satellite communications: future broadband satellite systems being planned to operate at Ka-band; and the next generation of mobile/personal satellite systems. Effective exploitation of the Ka-band will require breakthroughs in system concepts, signal processing, microelectronics and antenna technologies to achieve the cost, size and performance targets required to make deployment of such systems effective.

Global personal satellite communications systems are expected to be in service by the end of this century through the deployment of up to four "Big LEO" low earth orbit systems.

As Canada's leader in satellite communications R&D, CRC's challenge is to assist Canadian industry in capturing its share of a growing $13 billion market. A key strategy is CRC's close collaboration with companies to develop and transfer commercially relevant intellectual property. Also, the current mobile satellite systems MSAT and Inmarsat have existing space segments which will still be in place beyond the year 2010. These present an opportunity for adoption of non-traditional mobile satellite communications technologies and services such as mobile multimedia.

Current Year Objectives

In 1997-98, CRC is working on:

- performing R&D on advanced system concepts for mobile, personal and broadband satellite networks to allow CRC to continue providing cogent technical advice to Industry Canada, CSA and Canada's space industry;

- collaborating with Canadian industry, universities, and international research organizations in developing key technologies and subsystems, including antennas, modulation and coding schemes, and RF components for proof-of-concept demonstrations and for technology transfer to industry;

- demonstrating CRC's Ka-band suitcase terminal technology using the NASA ACTS satellite at various venues including the White House Communications Group;

- supporting military extra-high frequency (EHF) satellite communications research by developing digital signal processing and RF technologies for trials over the United Kingdom's Skynet satellite and participating in simulator trials with the United States;

- managing, on behalf of CSA, technology development programs positioning Canadian companies to compete in the global satellite communications market; and

- providing national technical leadership by coordinating the development of the satellite communications program for the third phase of Canada's Long Term Space Plan.

Broadcast Technology

CRC's broadcast technology R&D program focuses on digital television (DTV), digital radio broadcasting (DRB) and datacasting, and the integration of these services into a broadband communications environment, including interoperability among delivery media and with other communications systems such as LMCS and PCS. The program is designed to support Industry Canada's statutory responsibilities in broadcast spectrum management and regulation. As well it provides information and technology transfer to Canadian broadcasters, equipment manufacturers and service providers to develop competitive products and services. The R&D work also has longer-term implications for wireless, broadband communications for fixed, portable and mobile reception to extend the Information Highway to mobile applications and providing multimedia services.

Although digital broadcast services are beginning to appear on the market, many technical issues remain to be fully resolved before new services can be completely implemented in Canada. Spectrum allocation and assignment plans that allow for the transition from analog to digital systems remain to be developed. Due to coverage overlap between Canada and the United States, negotiation and agreement will be required for compatible frequency allocation plans in both countries. The issue of compatibility among delivery media also needs to be resolved to achieve a coherent DTV infrastructure.

The concept of mixed terrestrial and satellite DRB has not yet been demonstrated, and DRB standards issues remain to be resolved with the United States.

CRC's broadcast technology R&D program addresses issues such as:

- optimization of the digital modulation schemes;

- development of RF electronics/antenna subsystems;

- coverage optimization; digital compression techniques; stereoscopic (3D) television and multi-channel sound;

- high-speed network and wireless applications; and

- evaluation of video and audio quality of sub-systems, including the development of the necessary objective and subjective assessment methods.

> The Information Highway is a digital communications route. Measures are under way to take full advantage of its possibilities by moving broadcasting from its present analogue basis to a new digital foundation. The result will be clearer, higher-resolution pictures, better sound and less signal degradation, as well as a new capability on the part of broadcasters to distribute data and value-enhanced services.
>
> *Building the Information Society: Moving Canada into the 21st Century*

To carry out its work, CRC has established specialized video and audio facilities that meet international standards and which are unique in North America.

On behalf of Canada, CRC continues to play a leadership role in contributing scientific and technical advice on broadcast standards and service implementation to international, regional and national fora.

CRC was one of the first to advocate using the International Standards Organization's (ISO) MPEG-2 standard for digital television in North America.

CRC's preeminence led to the International Telecommunications Union - Radiocommunication Sector (ITU-R) allocation of the 1.5 GHz band for combined terrestrial and satellite DRB.

CRC has achieved international recognition for its service coverage simulation capability and for prediction and spectrum management tools that satisfy DRB and DTV service planning needs.

CRC's digital broadcast technology R&D is recognized worldwide, and CRC remains the only establishment in North America, capable of undertaking this work so comprehensively. CRC will also use its expertise in digital sound and video technologies and apply them to new information and multimedia services that will be offered on the Information Highway.

Current Year Objectives

In 1997-98, CRC is working on:

- identifying digital television and digital radio system requirements and specifications to support Industry Canada in finalizing a Canadian spectrum allocation plan for digital broadcast services, and to provide technical support to the federal government's task forces for implementing digital television and digital radio;

- developing a more powerful version of the coverage prediction program that will permit customization for various service requirements, including military wireless communications applications, and promoting the increased use of this software worldwide as a reference tool to design and predict service coverage;

- conducting extensive propagation studies and data broadcast experiments using the Ottawa DRB multi-transmitter site in cooperation with Digital Radio Research Incorporated;

- demonstrating a concept to enable mobile Internet access using DRB technology whereby information requests are made over the cellular telephone network and the results downloaded to the mobile terminal using a DRB channel;

- carrying out studies and experiments on wide-band broadcast systems, such as MMDS (multi

channel multipoint distribution system) and LMCS, and on datacasting using very-high and ultra-high frequency (VHF/UHF) television transmission facilities;

- in collaboration with international laboratories and standards organizations, developing low bit-rate video and sound compression algorithms, for application to next generation broadcast systems and multimedia services; and

- investigating technical and human perceptual aspects for stereoscopic (3D) television, and ensuring its compatibility with the emerging DTV services. Stereoscopy is considered to be the next significant enhancement in television broadcasting.

Radio Science

CRC's radio science program focuses on studying and quantifying the physical limits to the reliability, quality and performance of radio systems. This includes: propagation effects, radio noise and interference, performance and radiating compatibility of antennas in their operational environments, and electromagnetic compatibility.

The R&D work involves extensive interaction with other organizations including the Canadian Institute for Telecommunications Research, ITU-R, NASA and the European Community. Research into the fundamentals of ionospheric structures and propagation are also undertaken in collaboration with both Canadian and foreign universities and other organizations. CRC is the only research establishment in Canada that has a comprehensive program of interrelated R&D activities in radio science.

The increasing demand for wireless communications places greater emphasis on the need to find better ways to utilize the radio spectrum. Studies are needed to better characterize the spectrum above 1 GHz, especially above 20 GHz where radio propagation characteristics are far from completely known.

To facilitate the orderly planning and development of radio spectrum usage in Canada, Industry Canada requires measurement of propagation data and development of propagation models. Improved knowledge of the characteristics of radio channels

will lead to techniques to overcome adverse effects, increase spectrum efficiency, and obtain overall better reliability of radio communications.

Potential problems are, among others, increased interference between users and immunity issues raised about the proliferation effects of electromagnetic radiation. Prediction studies of near and far-fields of a portable radio handset are of critical interest to Industry Canada in order to ensure conformity with safety standards established by Health Canada and to establish safe areas of operation of electronic equipment from the immunity perspective.

The results of CRC's radio science program provide the needed information and advice to Industry Canada and industry to plan, develop and implement radio systems and services, in particular, to extend radiocommunications to unused portions of the radio spectrum. New services such as digital broadcasting and digital fixed and mobile communications demand radio propagation knowledge and channel modelling in much more detail and in different forms than was the case for analog systems. These R&D results also strongly influence spectrum allocation decisions made internationally by the ITU-R.

Current Year Objectives

In 1997-98, CRC is working on:

- undertaking satellite and terrestrial radio propagation measurements, and carrying out channel modelling studies in the range of 1 to 60 GHz pertinent to the design, operation, and regulation of such radiocommunication systems. The work meets the knowledge requirements of regulatory authorities in Industry Canada and radiocommunications service providers in industry. CRC is developing improved propagation prediction techniques for civilian and military radiocommunications needs;

- studying the characterization of the electromagnetic fields around cellular and other VHF/UHF portable transceivers and, thereby, ensuring conformity with safety standards established by Health Canada, and proposing safe areas of

operation of electronic equipment from an immunity perspective; and

■ building a centre of expertise in computational electromagnetic modelling by working with other groups to develop a capability that will enable a number of electromagnetic modelling codes to be

applied to several problems. This modelling work can be applied to research into characterizing near and far-fields from transmitting antennas used in urban areas; and is working with DND in the electromagnetic protection area, namely, high power microwaves and neutralization of land mines.

Broadband Networking

CRC's broadband networking program focuses on addressing Information Highway issues of primary interest to Canada such as: delivery of broadband services to remote regions of the country; interoperability between wireline and wireless services; network security; and convergence of communications, broadcast and computer technologies.

One of the key issues facing the implementation of a ubiquitous broadband network for Canada's Information Highway is the need for complete interconnectivity and interoperability between existing and emerging communications networks.

Another objective of CRC's broadband networking program is support of an evolving broadband network infrastructure which will use leading-edge Canadian technologies. This will be partially accomplished through the deployment of a prototype and experimental intra-city network as part of a government laboratory/industry working group. Connectivity to both satellite communications and terrestrial wireless systems will provide a fully integrated CRC testbed for technology and applications development, as well as for interoperability testing.

CRC has taken a leadership role in high-speed communications by implementing its Broadband Applications and Demonstration Laboratory (BADLAB) which is connected to the Ottawa Carleton Research Institute's OCRInet, and through CA*net2 to the rest of Canada. Through partnership with Teleglobe Canada and Telesat, BADLAB is connected to Europe using the CANTAT-3 fibre cable and to Japan via satellite.

Coverage to areas of Canada not serviced by fibre, as well as selective coverage to the United States, is provided by satellite links. By working with research partners, service providers, and international orga-

nizations, CRC plays a catalytic role in applications development, while working on interoperability issues.

One of the connectivity issues CRC's BADLAB faces is access for multiple users. Significant upgrading to the internal CRC infrastructure is needed to support bandwidth-hungry applications, such as computer-supported collaborative work using multicasting backbone tools, HDTV video conferencing and video-on-demand. CRC participates in the European Community's MERCI project, which provides support for collaborative R&D using enhanced multimedia tools.

CRC is participating as a significant player in both R&D and applications of broadband networking. Trials and experiments are verifying new technologies, Quality of Service (QoS) concepts, and compliance with standards and regulations.

CRC is gaining insights into other technical issues such as interoperability, signalling and control, bandwidth management, access and network security. Projects carried out by CRC primarily in support of DND requirements, are also contributing to the evolution of a Canadian broadband network infrastructure.

Asynchronous transfer mode (ATM) is a leading technology for delivery of multimedia services over satellite to remote communities. CRC is continuing to work with its partners to demonstrate and assess new hardware and applications with increasing emphasis on progressively more sophisticated versions of "bandwidth-on-demand".

One of the major issues related to the broadband infrastructure is its connection with existing and emerging wireless services. A number of technical

challenges must be overcome including scalability to access wideband services over narrowband links and effective user access techniques. CRC has already successfully connected its broadband network gateways with satellite communications, and will work on similar connectivity issues with terrestrial wireless systems.

Current Year Objectives

In 1997-98, CRC is working on:

- facilitating the ATM technology integration into DND/Canadian Forces networks and demonstrating ATM technology to government and industry. This includes providing the extension of ATM technology to non-fibre bearers. The ACCORD Project, a cooperative activity among organizations from Australia, Canada, the United Kingdom and the United States, is a major component in meeting these objectives;

- contributing, as a partner in the MERCI project, to the successful deployment of multimedia network technologies through R&D on protocols to support multimedia conferencing, end-user network services, performance measurement tools, and user interfaces to multimedia systems;

- participating in European experiments, under which various international networks are integrated to provide broadband applications support functions based on ATM, in order to contribute to consensus building for the advancement of international standards for broadband network interconnectivity; and

- setting up an internal broadband network at CRC which would allow desktop connectivity to all

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Only open standards, universally adopted within Canada and around the world, will allow Canada's Information Highway to develop into an interconnected and interoperable network of networks, where access to one network means access to all.

Building the Information Society: Moving Canada into the 21st Century

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networks accessed by BADLAB, and would also provide the research community with the required tools to undertake collaborative projects using interactive multimedia applications.

Optoelectronics and Photonics

CRC's optoelectronics and photonics program develops components to increase the capacity, versatility and performance of fibre-optic broadband networks. Emphasis is on those technologies which support the evolution of multiwavelength optical networks, which are expected to become a main underlying infrastructure for high bandwidth transport and switching. The ability of photonics technologies to carry very large bandwidths and to cost-effectively partition this bandwidth dynamically as the user desires will enable ubiquitous integrated voice, data, image and video communications.

As a leading supplier of telecommunications equipment, Canada is well-positioned to exploit advances in optoelectronics and photonics incorporated into products and services for the world marketplace. CRC has been active in this area for over 20 years and has accumulated a valuable intellectual property portfolio, as well as a solid international reputation for research excellence and technology transfer. There are a number of photonics-related R&D programs in university and government laboratories, as well as a growing industrial market for CRC's successful research outputs.

CRC is currently working with several major Canadian organizations in implementing a prototype high-capacity (20 gigabits/second) multiwavelength ring within the Ottawa-Carleton Region. It is worth noting that all of the critical enabling components will be designed, fabricated and assembled in Canada. It is intended that synergy between the optoelectronics and photonics research and the BADLAB and associated testbeds will be increased to provide demonstration vehicles for technological developments.

CRC continues to develop working partnerships with other establishments with complementary strengths in order to enhance photonics research in Canada, and with international organizations to develop and market intellectual property.

Current Year Objectives

In 1997-98, CRC is working on:

- exploring and developing those optoelectronic and photonic components which are expected to become critical building blocks for high-capacity networks, for example, fibre-optic multiplexers/demultiplexers/filters, laser array and detector subassemblies, optical switches, and components for dispersion compensation in fibres; and

- exploring the use of multiwavelength optical network technology in an intra-city operational environment and the use of advanced photonic components as value-added technologies in a multiwavelength network (including trade-offs between optical and electronic devices), evaluating new services and equipment, and testing network access, management and control issues.

Applications Demonstrations

CRC's applications demonstrations program focuses on stimulating a broader Canadian interest in new communications concepts, technologies and techniques and, thus, promotes more rapid understanding, acceptance and exploitation of them. Demonstrations are an excellent, and often necessary way to prove CRC-developed concepts and technologies, and give visibility and profile to CRC. Technology demonstrations are often closely tied to specific R&D initiatives undertaken in one of the key technology areas. However, CRC's application demonstrations are frequently collaborations with Canadian and international partners.

As a primary hub for application demonstrations involving domestic and international organizations, CRC continues to show national leadership. The establishment of the BADLAB, and its interconnection with the satellite communications testbed facility, has enabled CRC to showcase numerous multimedia demonstrations of international scope during the past three years. Other communications facilities and testbeds throughout CRC can be linked into application demonstrations configurations and these possibilities will be explored.

A major outcome of the application demonstrations program is the extension of CRC's R&D outputs to a broader community of users. This program will assist industrial partners in testing applications and help create business opportunities for small and medium-sized enterprises. For example, applications such as tele-medicine and tele-education, using satellite communications, will have positive social benefits by extending information services to

remote communities. Working with the international community in applications trials will help sustain and enhance Canada's image as a major player in telecommunications R&D.

Current Year Objectives

In 1997-98, CRC is working on:

- participating with Japan, the United States and the European Community, as part of the Global Interoperability for Broadband Networks (GIBN) project, in demonstrating a wide range of applications, including multi-site, multimedia conferencing, HDTV conferencing, and video-on-demand services using HDTV and present-day television formats;

- demonstrating, in collaboration with the European Community, the potential of computer-supported work of national and international teams (e.g., the design and modelling of aircraft parts) using distributed resources via high-speed networks;

- investigating the viability, in collaboration with Algonquin College (Ottawa) and OCRI, of delivering interactive multimedia courses over a broadband ATM network (OCRInet); and

- contributing to the implementation of satellite communications infrastructure and the ATM network gateways for the University of Ottawa Heart Institute trials investigating methods for medical consultation and patient diagnosis in rural and northern areas of Canada.

Testbeds and other specialized facilities are important vehicles for demonstrating the results of CRC R&D and facilitating access to CRC's capabilities. As described in the R&D Plan, testbeds are being expanded and more effectively integrated with the R&D program.

CRC is developing a new plan for facilities and space utilization. This will incorporate new development concepts consistent with CRC's "Open for Business" philosophy.

The Shirleys Bay site is shared with two major tenants -- laboratories of DND and CSA. In addition, several companies lease space on the site for R&D collaboration purposes. Approximately 700 people are employed full time, and up to 200 visitors enter the site each day.

As site property manager, CRC provides a range of services to all tenants including Facilities Management, Plant Engineering, and Safety and Security. Innovative ways to improve the efficiency of these services are being sought. For example, substantial utility savings are now being realized as a result of a major retrofitting initiative undertaken with a private company over the last two years.

Resources permitting, CRC will modify and develop the site to make the facilities more accessible for partners and visitors, without compromising security, and to create new kinds of space to encourage new activities and more effective interaction.

CRC is examining ways to enhance the contribution of services that directly support the R&D program. Ready access to services such as the Library, Creative Visual Services, Informatics, and Model Shop is essential to an efficient R&D operation. CRC is enhancing its informatics services and integrating them more effectively into the operation. Opportunities to enhance the capabilities and linkages of other services are being examined.

CRC's principal clients are Industry Canada, the Department of National Defence, and the Canadian Space Agency. Efforts directed toward these federal organizations will be designed to ensure that they continue to receive high value for their investment, and to seek opportunities to provide new value and new services.

While not generating revenues directly, financial leverage through collaboration is the most economical means to expand the scope and impact of CRC's R&D program. CRC's interactions with other organizations take two forms: collaboration primarily through in-kind contributions or joint undertakings; and contracting-in where clients pay for specific deliverables.

Collaboration with partners committing real resources and making meaningful in-kind contributions enhances the return on federal funding, supports CRC's vision-driven goals, and can open up opportunities for revenue-generating activity. It can also raise additional sustaining resources.

Leveraging Resources Through Partnerships in R&D

Continued building of institutional relationships is important to the achievement of CRC's goals. The institute will build on its past experience to create new and strengthened partnerships that enable CRC to magnify the return on public investment.

As a top priority, CRC is expanding its partnership with the National Research Council of Canada, focusing on joint R&D, support to SMEs and services such as electronic publishing of technical papers and research reports. CRC is also actively participating with NRC's Industrial Research Assistance Program to evaluate communications technology development proposals.

Other key alliances include:

- CSA for cooperative delivery of major satellite communications programs;

- R&D networks such as Canadian Network for the Advancement of Research, Industry and Education (CANARIE), the Tele-learning Research Network, OCRInet, and Digital Radio and Research Incorporated (DRRI);

- industry associations such as the Canadian Advanced Technology Association (CATA), Canadian Association of Broadcasters (CAB), Advanced Broadcasting Systems of Canada (ABSOC) and the Canadian Wireless Telecommunications Association (CWTA);

- Corporate partnerships such as: Teleglobe Canada, Telesat, NorthwesTel, Rogers Broadcasting, CBC, among others.

Increasing CRC Revenue Generation

CRC's core federal government funding is being reduced. To maintain critical mass in areas of essential core competency, and to finance new vision-driven initiatives, CRC must expand its revenues.

CRC is intensifying its promotion of services that generate revenues including: R&D contracts; intellectual property; fees for use of space and equipment; and technical and site services.

In 1996-97, non-government revenues totalled approximately $702,000 for intellectual property, and $973,000 for research and related services performed by CRC under contract. In 1997-98, the target for these revenues is $2.5M.

Other marketing priorities include the promotion of unique laboratory facilities, and generating publicity for CRC's marketable technologies to attract high technology entrepreneurs to CRC licencing opportunities.

Products and Services

CRC's primary product is knowledge and know-how in various forms, including its intellectual property portfolio. CRC is intensifying its diligence in protecting its intellectual property (IP) from infringement, and expanding its IP marketing efforts.

CRC's primary service is advice and information, mainly for government clients. In 1997 CRC is launching **an annual technology outlook program**, consisting of consultations, seminars, and published information, initially for CRC's government clients.

CRC's other services include professional R&D on a contract basis, access to facilities and specialized equipment, training, and project management.

CRC contributes significantly to the supply of highly qualified personnel in industrially-relevant communications R&D. Typically, more than forty graduate and undergraduate students are working within the research programs at any given time and CRC has a goal to expand this contribution.

CRC is expanding its training role based on its unique capabilities in science and technology. The priority will be to collaborate with educational institutions and other training providers in delivering courses that meet industry demand. To accommodate this new direction, CRC is improving its on-site training facilities.

Markets

In 1997-98, CRC's marketing efforts are being targeted in selected niche markets. Special teams combining R&D and business development personnel organize and execute the campaigns.

As outlined previously, a special focus will be on Industry Canada, to meet the Department's broad needs in areas such as spectrum management, Information Highway and industry development. In addition, a team is directing CRC's marketing efforts aimed at SMEs across Canada, using the CRC Innovation Centre and testbeds such as the BADLAB, Audio Perception Lab and ATEL as key vehicles.

These marketing efforts are being supported by continuing promotional efforts designed to give CRC broad visibility, identify new opportunities, and generate leads for follow-up by marketing teams.

Strengthening Marketing at CRC

The marketing efforts of CRC will be led and coordinated by the corporate marketing group. To some degree however, marketing is the responsibility of all CRC employees. Each is an ambassador when dealing with external clients, with the potential to open doors to new business or initiate relationships leading to business deals.

The corporate marketing group can identify opportunities, help researchers understand markets and new clients, and open doors to possibilities for deals which will, in most instances, be finalized by the R&D professionals. Thus the role of the corporate marketing group will be a combination of lead generation, facilitation and customer service.

To make this arrangement work most effectively the following steps are being taken:

- promotion of the importance of marketing and client relations throughout CRC;

- clarification of the expectations placed on R&D personnel with regard to marketing and revenue generation;

- formation of marketing teams based on partner ship between R&D and business development personnel; and

- provision of tools and training to all personnel involved in marketing.

CRC's International Role

International activities help CRC serve Canada more effectively. Examples include participation in:

- IEEE scientific and technical activities to obtain intelligence and information and access to expertise;

- ITU study groups to influence international standards in Canada's favour;

- international satellite programs to lever the capabilities of other countries to position Canada in international markets, and create specific opportunities for Canadian companies;

- international joint projects to demonstrate the application of CRC technologies and capabilities to the solution of international communications challenges, for example, the G-7 Nations' Global Interoperability Broadband Network (GIBN); and

- cross-licensing to open up international markets for Canadian technologies, and to give Canadian companies preferential access to technologies.

In addition, CRC is involved in an increasing range of international projects some of which generate revenues.

The WTO general agreement on telecommunications services will further open up international markets and create opportunities for CRC. In this context, CRC is continuing its selective international activity, guided by the following principles:

- international opportunities will be pursued only where there is demonstrable benefit to Canada;

- priority will be placed on opportunities in which CRC can support Canadian companies seeking to export; or

- can generate revenues in projects with follow-up business potential.

CRC exists in an environment of rapid technological, political, social and economic change and requires a governance framework that encourages innovative approaches to R&D management.

Being on the cutting edge of R&D management is not new to CRC. CRC has been a Lortie-model research institute since October 1993, embracing the philosophy and many of the recommendations contained in the National Advisory Board on Science and Technology report. It provided a corporate governance framework for CRC that was premised on a full understanding of the "culture" of S&T and focused on the management functions that are key to the successful performance of R&D organizations.

CRC has established a board of directors, appointed a president who reports to the deputy minister, and developed business and strategic planning documents. The remaining critical component of the corporate governance framework to be established by management this year is an accountability framework and contractual relationship with Industry Canada.

CRC's commitment to national leadership in collaborative research and development on innovative communications and information technologies requires greater flexibility and responsiveness to change.

CRC is developing an integrated planning process and accountability framework to:

- support Industry Canada's mission;

- remain responsive to its constituencies by anticipating client's needs and new opportunities;

- align the laboratory toward common goals;

- provide a process for increasing visibility and value;

- outline a transparent process for long-term strategic planning and shorter-term business planning;

- nurture core capabilities and guide business operations;

- allocate resources in accordance with well-defined priorities; and

- introduce rigour to the setting of R&D priorities, establish clear goals, define expected results and identify new methods of assessing the socio-economic impacts of CRC R&D.

Planning and Evaluation Framework

The Strategic Planning process will provide research projects with statements of measurable results. An Evaluation Framework is being developed to ensure that the expected results and outcomes of research endeavours are well understood and clearly defined at the outset. Meaningful performance indicators will be developed to capture results and determine the socio-economic impacts of the work performed at CRC, in keeping with new performance reporting requirements being introduced by the Treasury Board. Performance information will create a better understanding of, and visibility for, CRC.

CRC is implementing a new financial information system which incorporates project accounting. CRC plans to capture financial information on project costs so that cost-benefit analysis may be performed. CRC is also preparing to introduce Activity Based Costing (ABC) as a means of allocating indirect and overhead costs in order to capture the full costs of R&D projects.
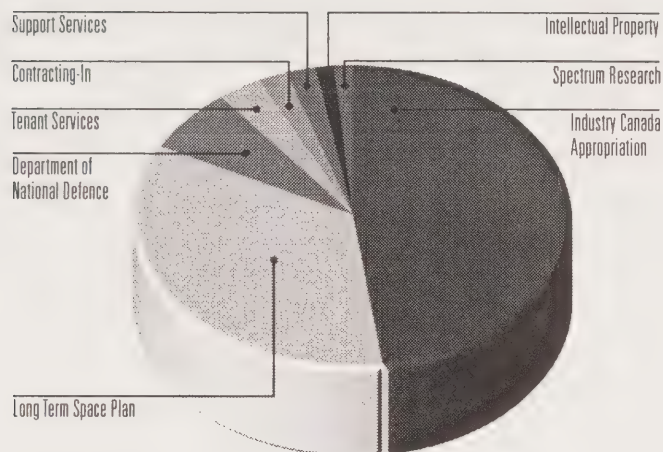
Revenues: ($000s)

Industry Canada Appropriation	$31,677.60
Long Term Space Plan	22,985.00
Department of National Defence	4,604.80
Spectrum Research	800.00
Contracting-In	1,500.00
Intellectual Property	1,000.00
Tenant Services	2,083.90
Support Services	1,412.00
Total:	**$66,063.30**
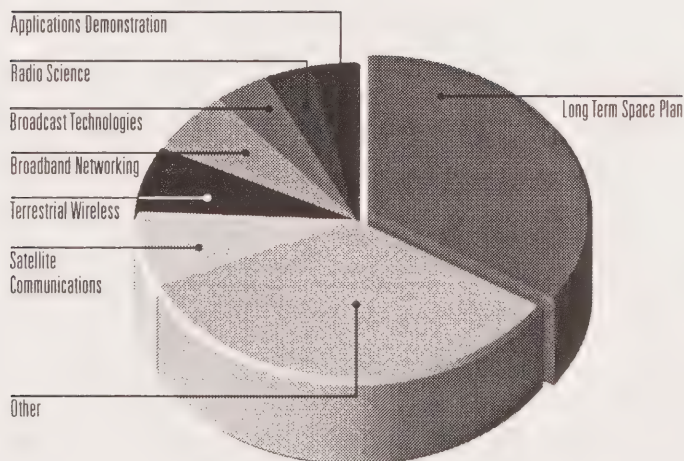
Projected Expenses (97-98): ($000s)

Terrestrial Wireless	$4,473.30
Satellite Communications	5083.80
Broadcast Technologies	2,646.00
Radio Science	2,438.20
Broadband Networking	4,240.00
Applications Demonstration	2,106.20
Long Term Space Plan	22,366.90
Other	22,708.90
Total:	**$66,063.30**

	1995-96	1996-97	1997-98	1998-99	1999-00
Revenues:	Actual....		Projected....		
Industry Canada	41,462.30	35,351.60 (1)	31,677.60 (2)	26,817.60	26,817.60
MSAT	38,700.00	3,600.00			
LTSP	6,237.00	9,929.70	22,985.00	24,985.00	11,330.10 (4)
Government	5,746.00	6,100.00	5,404.80	5,404.80	5,404.80
Private Sector	2,721.00	2,639.80	2,500.00	3,200.00	3,900.00
Tenant & Support Services	3,690.00	3,858.40	3,495.90	3,495.90	3,495.40
TOTAL REVENUES:	98,556.30	61,479.50	66,063.30	63,903.30	50,948.40

Expenses:					
Research	28,244.70	22,833.00	21,453.20	21,453.20	22,153.20
MSAT	38,700.00	3,600.00			
LTSP	6,237.00	9,929.70	22,366.90	24,366.90	10,712.00
Research Support	16,280.30	17,725.00	15,087.30	14,587.30	14,587.30
Tenant & Support Services	3,690.00	3,858.40	3,495.90	3,495.90	3,495.90
Extra-ordinary Item [3]	5,404.30	3,533.40	3,222.00		
TOTAL EXPENSES:	98,556.30	61,479.50	66,063.30	63,903.30	50,948.40

(1) Includes 3.5M for CITI budget and Departure Costs.

(2) Includes 500K for Showcase of World Class Technology and 479K for Departure Costs.

(3) Financial obligations to CITI, funding in 1997-98 includes 1.5M which will be rolled into 1998-99 to meet funding obligations in that year.

(4) Increased funding proposed for the LTSP in this year is subject to approval of the Phase III LTSP.

ABSOC
Advanced Broadcasting Systems of Canada

ACCORD
Advanced Command and Control Operations
Research and Development

ACTS
Advanced Communicatons Technology Satellite

ASIC
Application-specific integrated circuit

ATM
asynchronous transfer mode

BADLAB
Broadband Applications and Demonstration
Laboratory

BDO
Business Development Office

Big Leo
Constellation of Low Earth Orbit
communications satellites

CANARIE
Canadian Network for the Advancement of
Research, Industry and Education

CANTAT-3
Canadian Transatlantic Telecommunications
(fibre optic cable)

CA*net 2
Next Generation Internet research
network

CASP
Canadian Advanced Satcom Program

CCMC
Canadian Centre for Marine Communications

CITR
Canadian Institute for Telecommunications
Research

CRC
Communications Research Centre

CSA
Canadian Space Agency

CSNI
Communications Systems Network Interoperability

CTN
Canadian Technology Network

DND
Department of National Defence

DRB
digital radio broadcasting

DTV
digital television

DLR
Deutsches Luftfahrt und Raum Institut -
German research institute

EHF
Extra High Frequency

ESA
European Space Agency

GIBN
Global Interoperablility for Broadband Networks

GTIS
Government Telecommunications and Informatics
Services

G-7
Group of Seven (leading industrial nations)

HDTV
High definition television

IEEE
International Association of Electrical and
Electronics Engineers

Inmarsat
International Maritime Satellite organization

IP
intellectual property

IP
Internet Protocol

INRS
Institut national de la recherche scientifique
(University of Quebec research centre specializing in
telecommunications)

IRAP
Industrial Research Assistance Program,
an NRC initiative

ISO MPEG-2
International Standards Organization Moving
Picture Experts Group (Audio)

ITU-R
International Telecommunications Union - Radio
communications sector

LAN
local area network

LMCS
Local multipoint communications system

LTSP
Long-term Space Plan

MERCI
Multimedia European Research Conferencing
Integration

MMDS
multi-channel, multipoint distribution system

MSAT
mobile satellite

NABST
National Advisory Board on Science and Technology

NASA
National Aeronautics and Space Administration

NATO
North Atlantic Treaty Organization

NRC
National Research Council

OCEDCO
Ottawa-Carleton Economic Development
Corporation

OCRI
Ottawa-Carleton Research Institute

PCS
Personal Communications Services

QoS
quality of service

RF
radio frequency

S & T
Science and Technology

Satcom
Satellite communications

Skynet
United Kingdom satellite

SME
small and medium-sized enterprise

TARA
Telecommunications Research Alliance

TRIO/ITCR
Telecommunications Research Institute of
Ontario/Infomation Technology Research Centre

VHF/UHF
very high frequency/ultra high frequency

WTO
World Trade Organization